WHAT IS CLAIMED IS:

1. A reaction mixture for producing a product saccharide, wherein the reaction mixture comprises an acceptor saccharide and a first type of plant or microorganism cell that produces: a) a nucleotide sugar, and b) a first recombinant glycosyltransferase that catalyzes the transfer of a sugar from the nucleotide sugar to the acceptor saccharide to form the product saccharide.

2. The reaction mixture of claim 1, wherein the cells are selected from one or more of the group consisting of bacterial cells, yeast cells, fungal cells, and plant cells.

3. The reaction mixture of claim 1, wherein the cells are permeabilized or otherwise disrupted.

4. The reaction mixture of claim 1, wherein the glycosyltransferase is a fucosyltransferase and the nucleotide sugar is GDP-fucose.

5. The reaction mixture of claim 1, wherein the glycosyltransferase is a sialyltransferase and the nucleotide sugar is CMP-sialic acid

6. The reaction mixture of claim 1, wherein nucleotide sugar is selected from the group consisting of UDP-Gal, UDP-Glc, UDP-Glucuronic acid, UDP-GalNAc, UDP-Galacturonic acid, GDP-mannose.

7. The reaction mixture of claim 1, wherein the first type of cell produces the nucleotide sugar at an elevated level compared to a wild-type cell.

8. The reaction mixture of claim 7, wherein the elevated level of the nucleotide sugar results from a deficiency in the ability of the cell to incorporate the nucleotide sugar into a polysaccharide normally produced by the cell.

9. The reaction mixture of claim **7**, wherein the elevated level of the nucleotide sugar is at least 10% higher than the level of the nucleotide sugar produced by the wild-type cell.

10. The reaction mixture of claim **9**, wherein the elevated level of the nucleotide sugar is at least 25% higher than the level of the nucleotide sugar produced by the wild-type cell.

11. The reaction mixture of claim **1**, wherein the nucleotide sugar is synthesized by an enzymatic pathway that includes one or more enzymes that are expressed from heterologous genes.

12. The reaction mixture of claim **11**, wherein the recombinant glycosyltransferase is a sialyltransferase, the nucleotide sugar is CMP-sialic acid and the heterologous gene encodes CMP-sialic acid synthetase.

13. The reaction mixture of claim **12**, wherein the acceptor saccharide is lactose and the product saccharide is sialyllactose.

14. The reaction mixture of claim **11**, wherein the recombinant glycosyltransferase is a β1,4-GalNAc transferase and the nucleotide sugar is UDP-GalNAc.

15. The reaction mixture of claim **14**, wherein the acceptor is lactose and the product saccharide is β1,4-GalNAc-lactose.

16. The reaction mixture of claim **11**, wherein the recombinant glycosyltransferase is a galactosyltransferase and the nucleotide sugar is UDP-Gal.

17. The reaction mixture of claim **16**, wherein the galactosyltransferase is an α1,3-galactosyltransferase and the product saccharide contains a terminal α1,3-linked galactose residue.

18. The reaction mixture of claim **11**, wherein the enzymatic pathway comprises a full or partial sugar nucleotide regeneration cycle.

19. The reaction mixture of claim **18**, wherein the nucleotide sugar is UDP-GalNAc and the sugar nucleotide regeneration cycle comprises a set of enzymes selected from the group consisting of:

UDP-GalNAc epimerase, UDP-GlcNAc pyrophosphorylase, GlcNAc-1-kinase, polyphosphate kinase and pyruvate kinase; and

UDP-GalNAc pyrophosphorylase, GlcNAc-1-kinase, polyphosphate kinase and pyruvate kinase.

20. The reaction mixture of claim **19**, wherein the reaction mixture further comprises a second cell type that produces a nucleotide that is used as a substrate for the sugar nucleotide regeneration cycle.

21. The reaction mixture of claim **20**, wherein the second cell type comprises an exogenous gene that encodes a nucleotide synthetase polypeptide that catalyzes the synthesis of the nucleotide.

22. The reaction mixture of claim **21**, wherein the first cell type comprises exogenous genes that encode a) a fusion protein that comprises a polypeptide having 3'-sialyltransferase activity and a polypeptide that has CMP-sialic acid synthetase activity; and b) enzymes that catalyze the synthesis of sialic acid from GlcNAc;

and the second cell type comprises an exogenous gene that encodes CMP-synthetase.

23. The reaction mixture of claim **21**, wherein the first cell type is *E. coli* and the second cell type is yeast or *Corynebacterium*.

24. The reaction mixture of claim **1**, wherein the first type of cell produces a second recombinant glycosyltransferase that catalyzes the transfer of a sugar from the nucleotide sugar to the product saccharide to form a further glycosylated product saccharide.

25. The reaction mixture of claim **24**, wherein the nucleotide sugar is UDP-Gal, the first recombinant glycosyltransferase is an β1,4-galactosyltransferase and the second recombinant glycosyltransferase is an α1,3-galactosyltransferase.

26. The reaction mixture of claim **25**, wherein the acceptor saccharide is Glc(R)β-O-R^1, wherein R^1 is -$(CH_2)_n$-COX; X is selected from the group consisting of OH, OR^2, -$NHNH_2$, R is OH or NAc; R^2 is a hydrogen, a saccharide, an oligosaccharide or an aglycon group having at least one carbon atom, and n is an integer from 2 to 18.

27. The reaction mixture of claim **25**, wherein the UDP-Gal is generated by enzymes that are expressed from exogenous genes that encode UDP-Gal 4' epimerase and UDP-Glc pyrophosphorylase.

28. The reaction mixture of claim **1**, wherein the cell further comprises: a) an enzymatic system for producing at least a second nucleotide sugar, and b) at least a second recombinant glycosyltransferase that catalyzes transfer of a sugar from the second nucleotide sugar to the product sugar.

29. The reaction mixture of claim **28**, wherein:

the first recombinant glycosyltransferase is a GlcNAc transferase and the first nucleotide sugar is UDP-GlcNAc; and

the second recombinant glycosyltransferase is a galactosyltransferase and the second nucleotide sugar is UDP-galactose.

30. The reaction mixture of claim **29**, wherein the reaction mixture forms lacto-N-neotetraose (LNnT).

31. The reaction mixture of claim **1**, wherein the reaction mixture also comprises at least a second type of cell that produces a) a second nucleotide sugar, and b) a second recombinant glycosyltransferase that catalyzes the transfer of the sugar from the second nucleotide sugar to the product saccharide.

32. The reaction mixture of claim **31**, wherein the first glycosyltransferase is a galactosyltransferase and the second glycosyltransferase is a GalNAc transferase.

33. The reaction mixture of claim **31**, wherein:

the first cell type comprises a recombinant β1,4-GalNAc transferase, a recombinant β1,4-Gal transferase, UDP-GalNAc and UDP-Gal; and

the second cell type comprises a recombinant α2,3-sialyltransferase and CMP-sialic acid.

34. The reaction mixture of claim **33**, wherein the CMP-sialic acid is produced from CTP and GlcNAc by an enzymatic system in the second cell type that includes recombinant enzymes CMP-sialic acid synthetase, GlcNAc epimerase, NeuAc aldolase, and CMP-synthetase.

35. The reaction mixture of claim **33**, wherein the acceptor saccharide is lactosylceramide or lyso-lactosylceramide and the product saccharide is ganglioside GM_2.

36. The reaction mixture of claim **33**, wherein the second cell type further comprises a recombinant α2,8-sialyltransferase.

37. The reaction mixture of claim **36**, wherein the acceptor is lactosylceramide or lyso-lactosylceramide and the product saccharide is GD_2.

38. The reaction mixture of claim **1**, wherein the reaction mixture also comprises a second type of cell that produces a nucleotide from which is synthesized the nucleotide sugar produced by the first type of cell.

39. The reaction mixture of claim **38**, wherein nucleotide produced by the second cell type and the corresponding nucleotide sugar are selected from the group consisting of:

UTP: UDP-Gal, UDP-GalNAc, UDP-GlcNAc, UDP-Glc, UDP-glucuronic acid, or UDP-galacturonic acid;

GTP: GDP-Fuc; and

CTP: CMP-sialic acid.

40. A cell that produces a product saccharide, wherein the cell comprises:

a) a recombinant gene that encodes a glycosyltransferase;

b) an enzymatic system for forming a nucleotide sugar that is a substrate for the glycosyltransferase; and

c) an exogenous saccharide acceptor moiety;

wherein the glycosyltransferase catalyzes the transfer of a sugar from the nucleotide sugar to the acceptor moiety to produce the product saccharide.

41. The cell of claim **40**, wherein the enzymatic system for forming a nucleotide sugar comprises cycle enzymes for regenerating the nucleotide sugar.

42. The cell of claim **40**, wherein the recombinant gene that encodes a glycosyltransferase is a heterologous gene.

43. The cell of claim **40**, wherein the cell forms the nucleotide sugar at an elevated level compared to a wild-type cell.

44. The cell of claim 43, wherein the elevated level of nucleotide sugar results from a deficiency in the ability of the cell to incorporate the nucleotide sugar into a polysaccharide normally produced by the cell.

45. The cell of claim 44, wherein the deficiency is due to a reduced level of a polysaccharide glycosyltransferase activity.

46. The cell of claim 40, wherein the product saccharide is produced at a concentration of at least about 1 mM.

47. The cell of claim 40, wherein the enzymatic system for forming a nucleotide sugar comprises an enzyme encoded by a heterologous gene.

Sub a2 48. The cell of claim 47, wherein the enzyme encoded by the heterologous gene is one or more of:

a GDP-mannose dehydratase, a GDP-mannose 3,5-epimerase, and a GDP-mannose 4-reductase;

a UDP-galactose 4' epimerase;

a UDP-GalNAc 4' epimerase;

a CMP-sialic acid synthetase;

a pyrophosphorylase selected from the group consisting of a UDP-Glc pyrophosphorylase, a UDP-Gal pyrophosphorylase, a UDP-GalNAc pyrophosphorylase, a GDP-mannose pyrophosphorylase, and a UDP-GlcNAc pyrophosphorylase;

a kinase selected from the group consisting of myokinase, pyruvate kinase, acetyl kinase, creatine kinase; and

pyruvate decarboxylase.

49. The cell of claim 48, wherein the nucleotide sugar is GDP-fucose.

50. A cell that produces a sulfated polysaccharide, the cell comprising:

a heterologous gene that encodes a sulfotransferase; and

an enzymatic system that produces PAPS.

51. The cell of claim **50**, wherein the sulfated polysaccharide is selected from the group consisting of heparin sulfate and carragenin.

52. The cell of claim **50**, wherein the enzymatic system that produces PAPS comprises one or more enzymes that are expressed from exogenous genes.

53. A method of producing a product saccharide, the method comprising contacting a microorganism or plant cell with an acceptor saccharide, wherein the cell comprises:

a) an enzymatic system for forming a nucleotide sugar; and

b) a recombinant glycosyltransferase which catalyzes the transfer of a sugar from the nucleotide sugar to the acceptor saccharide to produce the product saccharide.

54. The method of claim **53**, wherein the glycosyltransferase is encoded by a heterologous gene.

55. The method of claim **53**, wherein the glycosyltransferase is encoded by a gene that is endogenous to the cell and is produced by the cell at an elevated level compared to a wild-type cell.

56. The method of claim **53**, wherein the product saccharide is produced at a concentration of at least about 1 mM.

57. The method of claim **53**, wherein the cell is permeabilized.

58. The method of claim **53**, wherein the cell is an intact cell.

59. The method of claim **53**, wherein the enzymatic system for forming a nucleotide sugar comprises an enzyme that is encoded by a heterologous gene.

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60. The method of claim **59**, wherein the enzyme encoded by the heterologous gene is one or more of:

a GDP-mannose dehydratase, a GDP-4-keto-6-deoxy-D-mannose 3,5-epimerase, and a GDP-4-keto-6-deoxy-L-glucose 4-reductase;

a UDP-galactose 4' epimerase;

a UDP-GalNAc 4' epimerase;

a CMP-sialic acid synthetase;

a pyrophosphorylase selected from the group consisting of a UDP-Glc pyrophosphorylase, a UDP-Gal pyrophosphorylase, a UDP-GalNAc pyrophosphorylase, a GDP-mannose pyrophosphorylase, and a UDP-GlcNAc pyrophosphorylase; a kinase selected from the group consisting of myokinase, pyruvate kinase, acetyl kinase, creatine kinase; and

pyruvate decarboxylase.

61. The method of claim **59**, wherein the enzyme for forming a nucleotide sugar and the glycosyltransferase are expressed as a fusion protein.

62. The method of claim **61**, wherein the fusion protein comprises a CMP-sialic acid synthetase activity and a sialyltransferase activity.

63. The method of claim **61**, wherein the fusion protein comprises a galactosyltransferase activity and a UDP-Gal 4' epimerase activity.

64. The method of claim **61**, wherein the fusion protein comprises a GalNAc transferase activity and a UDP-GlcNAc 4' epimerase activity.

65. The method of claim **53**, wherein the nucleotide sugar is GDP-fucose and the glycosyltransferase is a fucosyltransferase.

66. The method of claim **53**, wherein the cell forms the nucleotide sugar at an elevated level compared to a wild-type cell.

67. The method of claim **66**, wherein the elevated level of nucleotide sugar results from a deficiency in the ability of the cell to incorporate the nucleotide sugar into a polysaccharide normally produced by the cell.

68. The method of claim **67**, wherein the deficiency is due to a reduced level of a polysaccharide glycosyltransferase activity.

69. The method of claim **53**, wherein the cell/nucleotide sugar are selected from the group consisting of:

Azotobacter vinelandii/GDP-Man;

Pseudomonas sp./UDP-Glc and GDP-Man;

Rhizobium sp./UDP-Glc, UDP-Gal, GDP-Man;

Erwinia sp./UDP-Gal, UDP-Glc;

Escherichia sp./UDP-GlcNAc, UDP-Gal, CMP-NeuAc, GDP-Fuc;

Klebsiella sp./UDP-Gal, UDP-GlcNAc, UDP-Glc, UDP-GlcNAc;

Hansenula jadinii/ GDP-Man, GDP-Fuc;

Candida famata/UDP-Glc, UDP-Gal, UDP-GlcNAc;

Saccharomyces cerevisiae/UDP-Glc, UDP-Gal, GDP-Man, GDP-GlcNAc; and

X. campesti/UDP-Glc, GDP-Man.

70. The method of claim **53**, wherein the cell is *Azotobacter vinelandii*, the nucleotide sugar is GDP-mannose, the acceptor saccharide is lactose, the glycosyltransferase is mannosyl transferase, and the product saccharide is mannosyl lactose.

71. The method of claim **53**, wherein the cell is *E. coli*, the nucleotide sugar is CMP-sialic acid, the acceptor saccharide is lactose, the glycosyltransferase is a sialyltransferase, and the product saccharide is sialyllactose.

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